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THERMO-MECHANICAL ANALYSIS OF HIGH TEMPERATURE INSULATING COMPOSITES

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ABSTRACT

The investigation highlights the influence of C-ph and C-ph-BN with different volume fractions and the densities of carbon phenolic with 30 – 70 V_f, finding thermal conductivity,Specific heat and the thermal diffusivity of this hybrid Composites. The main objective is to find the thermal properties which are varying with respect to the Composition. The novel models are set for fluid thermal interactions and are compared and validated.

***KEYWORDS**: fluid thermal, C-ph &C-ph-BN*

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Original Article

INTRODUCTION

The Thermal Protection System (TPS) is the barrier that protects the space shuttle orbiter during the searing heat of atmospheric reentry. A secondary goal was to protect from the heat and cold of space while in orbit.There are 2 types of TPS one is Ablative and other Non ablative (Ceramic). Ablative TPS used for critical reentry space missions, as it can absorb more heat Carbon-phenolic and is one of the best ablative composite. Ultra high temperature ceramics are non-ablative TPS and can also be used inside the thruster nozzles. UHTC can be used for several missions while ablative type TPS cannot be used more than once. There are several examples of these two kind of TPS but still needs improvement. Ultra high temperature ceramics (UHTC) are brides, carbides, nitrides of transition metals. UHTCs being developed during the last 15 years and ceramics made of boardes are used more because brides form strong bonds and also the oxidation resistance, thermal shock resistance are high with low thermal expansion. Ablative TPS used when the thermal insulation required is quite high. Carbon is observed to be the most thermal insulating fiber. Phenolic is a thermo set resin which will undergo pyrolysis when subjected to high temperatures. Addition of thermal insulating materials to this carbon phenolic composite will tend to improvise the thermal properties of composites. There are draw backs in addition of materials to carbon phenolic. Research work is going on these hybrid composite materials. Thermo-mechanical analysis of a structure will idealize the thermal loads applied to the structure.

MATERIALS AND METHODS

Materials

- **Carbon Phenolic (C-Ph)**

  30, 200, 380 gsm carbon fibers are used. The phenolic percentage will differ in each of the carbon fiber. Hot press is used as to avoid the void spaces in the composite. No leakages are allowed.

- **Carbon Phenolic (C-PH-BN)**
  - Boron nitride is a material with less thermal conductivity and high specific heat. Boron nitride creates porosity in the composite which increases the thermal absorption in the composite.
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Method

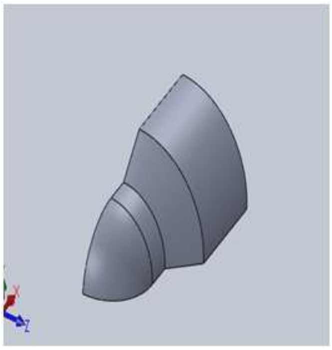
Varying the volume fractions (**vf**) the densities of carbon phenolic and thermal conductivity of Carbon and phenolic, Specific heat of carbon and phenolic, thermal diffusivity values are calculated.

Table 1

Vf	The Densities of Carbon Phenolic with 30 – 70 Vf are	Thermal Conductivity of Carbon and Phenolic 30 – 70 Vf are	Specific Heat of Carbon and Phenolic 30 – 70 Vf are	The Thermal Diffusivity Values are
30	1.36	3.24	6.95	3.4
40	1.42	4.27	6.07	4.93
50	, 1.48	5.3	5.19	6.89
60	1.53	6.33	4.31	9.55
70	1.59	7.36	3.43	13.45 X 10-6 m/s

COMPUTATIONAL ANALYSIS

Design



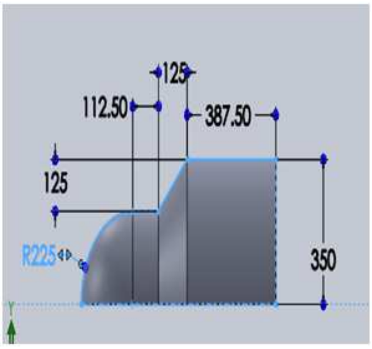


Figure 1: Design of Hybrid Composite Material **Figure 2: Dimensions of Hybrid Composite Material**

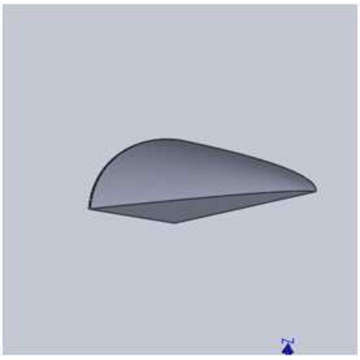


Figure 3: Design of Hybrid c –Ph Materials

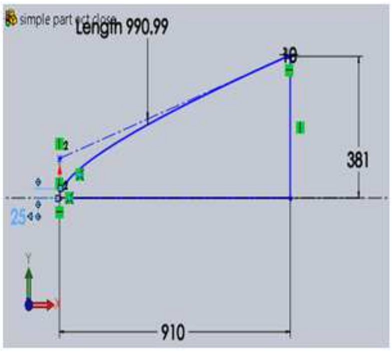


Figure 4: Design of Hybrid c –Ph-BN Materials

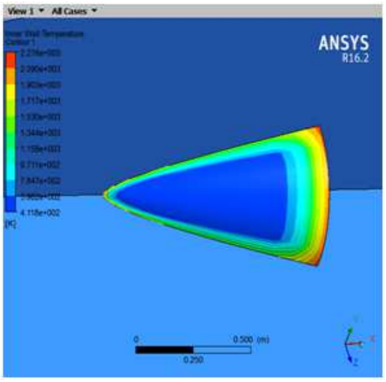


Figure 5: Thermal Interaction of the Model c –ph(Inner Wall Temperature)

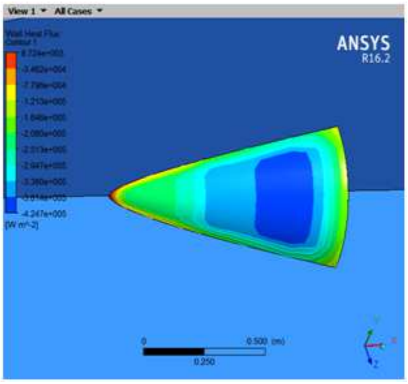


Figure 6: Thermal Interaction of the Model c-ph-BN(Wall Heat Flux)

EXPERIMENTAL ANALYSIS

Figure 7: Fabrication Model of c-ph

Figure 8: Fabrication Model of c-ph-BN

HYBRID COMPOSITES

Composites with different compositions of zirconium di boride, zirconium dioxide, silicon dioxide, carbon fiber. With the composition of layers of these materials a layer of the composite is made.

Properties of HC-IA and HC-IB

Figure 9: Hybrid Composites Materials IA

Figure 10: Hybrid Composites Materials IB

Figure 11: HCIA and HCIB Fabrication of Hybrid Composite Models

Testing

- ASTM standards are used to calibrate the properties of the composites.
- ASTM D790 is used for flexural rigidity.
- ASTM D2344 is used for inter laminar shear stress.
- ASTM E285 is used for thermal testing.

RESULTS

The thermal conductivity varies between 3.2 to 7.3 W/MK and specific heat varies between 6.95 to 3.43 KJ/KgK, thus the back face temperature ranges in between 372 to 482 K for 30 to 70 the volume percentage of fiber. In C-PH-BN linear ablation rate varies in between 0.08 to 0.05, mass ablation rate varies from 0.1 to 0.06, back face temperature will be 150 to 200 ^{0}C .Thermal conductivity ranges between0.02 to 0.03 W/MK and specific heat is 1.15 to 1.22 J/KgK. Hybrid composite ablation rates are 0.08, 0.045, 0.05 for blank, HC1, HC2 respectively.Thermal conductivity is 0.4 for both HC1 and HC2 Back face temperature is reduced almost 25% when compared to blank.

CONCLUSIONS

C-Ph with different volume fraction,V_f, 200 gsm sample has good thermal property but mechanical properties are comparatively less. C-Ph-BN with an increase in BN, the EI and ILSS are increasing therefore there is an increase in

thermal properties. Hybrid composite has excellent thermal properties, but HC_2 has less compared to HC_1The thermal profile of the model with fluid thermal interaction has more temperature at the node of range 2000 degrees.

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